Market Reforms at the Zero Lower Bound*

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Abstract

This paper studies the impact of product and labor market reforms when the economy faces major slack and a binding constraint on monetary policy easing—such as the zero lower bound. To this end, we build a model with endogenous producer entry, labor market frictions, and nominal rigidities. We find that while the effect of market reforms depends on the cyclical conditions under which they are implemented, the zero lower bound itself does not appear to matter. In fact, when carried out in a recession, the impact of reforms is typically stronger when the zero lower bound is binding. The reason is that reforms are inflationary in our structural model (or they have no noticeable deflationary effects). Thus, contrary to the implications of reduced-form modeling of product and labor market reforms as exogenous reductions in price and wage markups, our analysis shows that there is no simple across-the-board relationship between market reforms and the behavior of real marginal costs. This significantly alters the consequences of the zero (or any effective) lower bound on policy rates.

JEL Codes: E24, E32, E52, F41, J64.

Keywords: Employment protection; Monetary policy; Producer entry; Product market regulation; Structural reforms; Unemployment benefits; Zero lower bound.

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1 Introduction

The protracted economic slowdown following the 2008-2009 global financial crisis and the limited room for additional monetary and fiscal stimulus put structural reforms at the center of the policy agenda in many advanced economies (e.g. Draghi, 2015, IMF, 2016, and OECD, 2015). As the Covid-19 crisis further depleted the macroeconomic-policy space, calls for market reforms will likely continue to play a central in the years to come.

A large body of theoretical and empirical research supports the view that such reforms would raise output and employment in the long run.[1] However, there is an active debate regarding short-term outcomes of market reform. A central issue involves the consequences of structural reforms at a time in which central banks face binding constraints on monetary policy easing, in particular because of the impossibility in pushing policy rates into negative territory unlimitedly—the so-called zero lower bound (ZLB) on nominal interest rates.[2] Two geographic areas where structural reforms have been advocated most forcefully, namely the euro area and Japan, are in such a situation. At the heart of the debate ultimately lies the question of whether market reforms have important deflationary effects. As argued by Eggertsson (2010), in a liquidity trap expectations of deflation increase real interest rates, thus depressing current demand—what he calls the paradox of toil. Building on this insight, Eggertsson, Ferrero and Raffo (2014) show that if structural reforms are interpreted as exogenous reductions in price and wage markups, deregulation may entail near-term contractionary effects when monetary policy is constrained by the ZLB, since reforms fuel expectations of prolonged deflation.[3] Even more disappointingly, if agents foresee that such reforms are not permanent (due to lack of political credibility), short-term output losses are even larger, further deepening the ongoing recession.

The analysis in Eggertsson, Ferrero and Raffo (2014) maintains the assumption that market reforms act as exogenous reductions in price and wage markups. However, from an empirical perspective, market regulation affects the incentives to create and destroy products and jobs. Price and wage dynamics are an endogenous outcome of market reform. The goal of this paper is to address the consequences of primitive changes in market regulation when the economy is in a deep

[1] See for instance the influential paper by Blanchard and Giavazzi (2003). Other theoretical papers include, for product market reforms, Ebell and Haefke (2009), Fang and Rogerson (2011), and Felbermayr and Prat (2011); for labor market reforms, Alessandria and Delacroix (2008), Alvarez and Veracierto (2000), Bentolila and Bertola (1990), and Hopenhayn and Rogerson (1993).

[2] Our arguments and analysis extend to any (negative) effective lower bound on the monetary policy rate.

[3] Eggertsson (2012) argues that New Deal policies facilitated the recovery from the Great Depression by temporarily granting monopoly power to firms and unions.

recession that has triggered the ZLB on nominal interest rates.

To this end, we build a model featuring endogenous producer entry, search-and-matching frictions in labor market, and nominal rigidities. Endogenous variation in the number of monopolistically competitive firms builds on Bilbiie, Ghironi and Melitz (2012) and Ghironi and Melitz (2005). Labor markets are characterized by search-and-matching frictions with endogenous job creation and destruction as in Mortensen and Pissarides (1994) and den Haan, Ramey and Watson (2000). We calibrate the model to match features of the euro-area macroeconomic data.

We then analyze the dynamic response of the economy to three different reforms that have featured prominently in policy debates over the years: i) product market reform, modeled as a reduction in regulatory costs of entry; ii) employment protection legislation reform, namely a reduction in firing costs; iii) a decline in the generosity of unemployment benefits, that is a cut in the average replacement rate over an unemployment spell. For each reform, we consider two alternative scenarios: i) market reform happens in normal times, i.e., when the economy is not in a recession and the ZLB is not binding; ii) in a crisis that pushes the nominal interest rate to its lower bound.

Our main conclusion is that while business cycle conditions at the time of deregulation matter for the adjustment, the presence of the ZLB does not, *per se*, induce recessionary effects of market reforms. In fact, reforms can be more beneficial when the ZLB is binding, as observed for product market and unemployment benefit reforms.

This result reflects the fact that reforms do not have deflationary effects in the first place, at least in the short run. The intuition behind this result is easily understood. Consider first a reduction in barriers to entry. While such reform reduces price mark-ups through well-understood pro-competitive effects, the downward pressure on prices is initially more than offset by two inflationary forces. First, lower entry barriers trigger entry of new producers, which increases demand for factors of production and thereby marginal costs. Second, incumbent producers lay off less productive workers in response to increased competition. Since remaining workers have higher wages on average, marginal labor costs rise. The latter effect also explains why lower firing costs—which induce firms to lay off less productive workers—are not deflationary either, even though layoffs reduce aggregate demand all else equal. Finally, while unemployment benefit cuts have a negative impact on wages and aggregate demand by weakening workers' outside option in the wage bargaining process, this deflationary effect is offset by the positive general equilibrium impact of the reform on labor demand, which increases wages other things equal.

Our results highlight that prevailing business cycle conditions and not constraints on monetary policy represent the key dimension to consider when evaluating the short- to medium-run effects of market reform. Moreover, our analysis shows that, contrary to what is implied by the conventional modeling of product and labor market reforms—exogenous price and wage mark-up reductions—there is no simple across-the-board relationship between market reforms and the behavior of the real marginal cost. This is because reforms affect both supply and demand in complex ways. Output and employment responses to reform vary widely across specific areas already in normal times, and how these responses are altered by the presence of a recession with a binding zero lower bound also differs across reforms. This reflects important differences, highlighted by our model, in the nature and transmission of different reforms. For instance, while reductions in firing costs and unemployment benefits both qualify as "labor market reforms", their short-term effects differ noticeably, and there is a significant "difference in this difference" between normal times and a recession with a binding ZLB.

Our paper relates to a burgeoning theoretical literature on the short-term effects of structural reforms, both in general and at the ZLB more specifically. Considering only normal times, Cacciatore and Fiori (2016) explore the short-term effects of the reforms discussed here, while Cacciatore, Duval, Fiori and Ghironi (2016a) and Cacciatore, Fiori and Ghironi (2016) assess the role of monetary policy for short-run adjustment to these reforms. Cacciatore, Duval, Fiori and Ghironi (2016b) explore the role of business cycle conditions for the short-term effect of market deregulation in a real model that ignores the role of monetary policy altogether. A number of large-scale DSGE models have also been used to analyze the dynamic impact of reforms in normal times (Varga and in't Veld, 2011; Everaert and Schule, 2008; Gomes, Jacquinot, Mohr and Pisani, 2013), although their focus is on exogenous reductions in price and wage markups.

A few recent papers study how the impact of reforms differs at the zero lower bound. Using a simple New Keynesian model with wage and price rigidities, Eggertsson, Ferrero and Raffo (2014) find that the impact of reforms that would be expansionary in normal times becomes a priori ambiguous, and possibly contractionary, at the ZLB. However, they model reforms in reduced-form fashion as exogenous reductions in price and wage markups; this makes reforms automatically deflationary in their basic setup.[4] Using larger-scale models of the euro area featuring richer transmission mechanisms—including investment, trade with the rest of the world, liquidity-constrained

[4] See also Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2011). Andrés, Arce, and Thomas (2017) study the consequences of market reforms in an environment of debt deleveraging. These papers—and others that have appeared in the literature—do not feature producer entry dynamics and DMP labor market frictions.

versus optimizing households—Gerali, Notarpietro and Pisani (2015), Gomes (2014), and Vogel (2014) reassess this result and find a smaller role of the ZLB. Explicit modeling of product and labor market dynamics and the primitive features of regulation differentiates our paper from these recent studies. As illustrated above, such modeling has major implications for the effects of reforms at the ZLB and how they vary across different areas.[5]

A few caveats are in order. Our analysis shows that market reform increases labor productivity both in the long run and in the short run, even when implemented at the ZLB. However, our modeling of product market reforms does not factor in possible productivity gains that may stem from reduced X-inefficiency among incumbent firms or from stronger incentives for them to innovate. Therefore, if anything, these other possible transmission channels suggest we may under-estimate the short-term effects of reforms, including at the ZLB.[6] In addition, our finding that unemployment benefit cuts do not have deflationary effects—and therefore that their effectiveness is not reduced by the presence of a binding ZLB—reflects the strong responsiveness of labor demand, and thereby of aggregate demand, to such reforms. The relevance of the firm hiring channel, highlighted also by Mitman and Rabinovich (2015), stresses more broadly the beneficial effects of labor market policies promoting wage flexibility (through reductions in the generosity of wage replacement) as opposed to employment flexibility during downturns. This result is consistent with the empirical evidence in Gnocchi, Lagerborg, and Pappa (2015) and echoes the discussion in Boeri and Jimeno (2015). However, the model abstracts from a potential counteracting force: a cut in unemployment benefits affects more severely lower-income, credit-constrained households, inducing them to curtail consumption. Furthermore, households typically become more credit-constrained—and therefore the counteracting force could become stronger—in recessions (Mian and Sufi, 2011). As argued by Kollmann, Ratto, Roeger, in't Veld, and Vogel (2015), even if the government fully redistributes the fiscal gain from benefit reductions through broad-based tax cuts, aggregate consumption may still decline and output fall.

[5] This recent literature on the effect of supply-side policies at the ZLB falls within the broader context of a growing body of work on how the ZLB may alter the impact of shocks relative to normal times. For fiscal policy shocks, see Christiano, Eichenbaum and Rebelo (2011), Erceg and Linde (2012), and Woodford (2011).

[6] Notice that productivity shocks are expansionary in our model, even at the ZLB—albeit less so than in normal times due to their depressing impact on prices.

2 The Model

In this Section, we present a general equilibrium model that features search and matching frictions, endogenous product creation, and nominal rigidities. We abstract from monetary frictions that would motivate a demand for cash currency and we resort to a cashless economy following Woodford (2003).

Household Preferences

There is a unit mass of atomistic, identical households. Each household is thought of as a large extended family containing a continuum of members along a unit interval. The household does not choose how many family members work; the measure of family members who work is determined by a labor matching process. Unemployed workers receive a fixed amount $h_p > 0$ of household production units. Following Andolfatto (1996), Merz (1995), and much of the subsequent literature, we assume full consumption insurance between employed and unemployed individuals.

The representative household maximizes expected utility $E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}\tilde{C}_s^{1-\gamma}/\left(1-\gamma\right)\right]$, where the discount factor β is between 0 and 1, and $\gamma > 0$. Household consumption $\tilde{C}_t$ is defined as $\tilde{C}_t \equiv C_t + h_p(1-L_t)$, where C_t is consumption of market goods, and L_t denotes the number of employed workers. Market consumption is a composite of differentiated varieties. We assume that the aggregator C_t takes a translog form following Feenstra (2003b). As a result, the elasticity of substitution across varieties within the basket C_t is an increasing function of the number of goods available. The translog assumption allows us to capture the pro-competitive effect of deregulating in the goods market on markups, documented by the empirical literature—see Griffith, Harrison, and Macartney (2007).[7] Translog preferences are characterized by defining the unit expenditure function (i.e., the price index) associated with the preference aggregator. Let $p_{\omega,t}$ be the nominal price for the good $\omega \in \Omega_t$. The unit expenditure function on the basket of goods C_t is given by:

$$\ln P_t = \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}}\right) + \frac{1}{N_t}\int\limits_{\omega\in\Omega_t} \ln p_t\left(\omega\right) d\omega + \frac{\sigma}{2N_t}\int\limits_{\omega\in\Omega_t}\int\limits_{\omega'\in\Omega_t} \ln p_t\left(\omega\right)\left(\ln p_t\left(\omega\right) - \ln p_t\left(\omega'\right)\right) d\omega d\omega', \tag{1}$$

[7] A demand-, preference-based explanation for time-varying, flexible-price markups is empirically appealing because the data shows that most entering and exiting firms are small, and much of the change in the product space is due to product switching within existing firms, pointing to a limited role for supply-driven competitive pressures in markup dynamics. For a review of the applications of translog preferences in the trade literature, see Feenstra (2003a).

where $\sigma > 0$ denotes the price-elasticity of the spending share on an individual good, N_t is the total number of products available at time t, $\tilde{N}$ is the mass of Ω, and $\Omega_t \in \Omega$ is the subset of goods available to consumers.

Production

At the upstream level, perfectly competitive firms use capital and labor to produce an intermediate input. At the downstream level, monopolistically competitive firms purchase intermediate inputs and produce differentiated varieties.

Intermediate Goods Production

There is a unit mass of perfectly competitive intermediate producers. Production requires capital and labor. Capital is perfectly mobile across firms and jobs and there is a competitive rental market in capital. While firms are "large" as they employ a continuum of workers, firms are still of measure zero relative to the aggregate size of the economy.

A filled job i produces $Z_t z_t^i \left(k_t^i\right)^a$ units of output, where Z_t denotes aggregate productivity, z_t^i represents a random disturbance that is specific to match i, and k_t^i is the stock of capital allocated to the job. Within each firm, jobs with identical productivity z_t^i produce the same amount of output. For this reason, in the remainder of the paper we suppress the job index i and identify a job with its idiosyncratic productivity z_t. As common practice in the literature, we assume that z_t is a per-period *i.i.d.* draw from a time-invariant distribution with c.d.f. $G(z)$, positive support, and density $g(z)$.[8] We assume that $G(z)$ is lognormal with log-scale μ_{z_i} and shape σ_{z_i}. Aggregate productivity Z_t is exogenous and common to all firms. We assume Z_t follows an $AR(1)$ process in logs: $\log Z_t = \rho_Z \log Z_{t-1} + \epsilon_{Zt}$, where $\epsilon_{Zt} \overset{i.i.d.}{\sim} N\left(0, \sigma_{\epsilon_Z}^2\right)$.

The representative intermediate firm produces output

$$Y_t^I = Z_t L_t \frac{1}{1 - G(z_t^c)} \int_{z_t^c}^{\infty} z k_t^{\alpha}(z)\, g(z) dz, \tag{2}$$

where the term z_t^c represents an endogenously determined critical threshold below which jobs that draw $z_t < z_t^c$ are not profitable. In this case, the value to the firm of continuing the match is less than the value of separation, and the job is destroyed. When terminating a job, each firm incurs

[8] The assumption of *i.i.d.* idiosyncratic productivity shocks eliminates the need to consider match-specific state variables for continuing relationships. Results in den Haan, Ramey, and Watson (2000) lead us to conjecture that this would not affect our results significantly.

a real cost F_t. Firing costs are a pure loss, including administrative costs of layoff procedures; severance transfers from firms to workers would have no allocative effects with wage bargaining (Mortensen and Pissarides, 2002). The relationship between a firm and a worker can also be severed for exogenous reasons; in which case, no firing costs are paid. Denote with λ the fraction of jobs that are exogenously separated from each firm in each period.

Job creation is subject to matching frictions. To hire a new worker, firms have to post a vacancy, incurring a real fixed cost κ. The probability of finding a worker depends on a constant returns to scale matching technology, which converts aggregate unemployed workers U_t and aggregate vacancies V_t into aggregate matches $M_t = \chi U_t^{\varepsilon} V_t^{1-\varepsilon}$, where $0 < \varepsilon < 1$. Each firm meets unemployed workers at a rate $q_t \equiv M_t/V_t$. Searching workers in period t are equal to the mass of unemployed workers: $U_t = (1 - L_t)$.

The timing of events proceeds as follows. At the beginning of each period, a fraction λ of jobs are exogenously separated. Aggregate and idiosyncratic shocks are then realized, after which the representative firm chooses the productivity threshold z_t^c that determines the measure of jobs endogenously destroyed, $G(z_t^c)$. Once the firing round has taken place, firms post vacancies, V_t, and select their total capital stock, $K_t = L_t \tilde{k}_t$, where $\tilde{k}_t \equiv \int_{z_t^c}^{\infty} k_t(z)\, g(z) dz / [1 - G(z_t^c)]$. The assumption that firms select capital after observing aggregate and idiosyncratic shocks follows den Haan, Ramey, and Watson (2000).

The inflow of new workers and the outflow of workers due to separations jointly determine the evolution of firm-level employment: $L_t = (1 - \lambda)(1 - G(z_t^c))(L_{t-1} + q_{t-1} V_{t-1})$. Separated workers immediately reenter the unemployment pool. As shown in Cacciatore and Fiori (2016), owing to perfectly mobile capital rented in a competitive market, the producer's output exhibits constant returns to scale in labor and capital: $Y_t^I = Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha}$, where

$$\tilde{z}_t \equiv \left[\frac{1}{1 - G(z_t^c)} \int_{z_t^c}^{\infty} z^{1/(1-\alpha)} g(z) dz \right]^{1-\alpha}$$

is a weighted average of the idiosyncratic productivity of individual jobs. Intermediate goods producers sell their output to final producers at a real price φ_t in units of consumption. Per-period real profits are given by

$$d_t^I = \varphi_t Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha} - \tilde{w}_t L_t - r_t^K K_t - \kappa V_t - G(z_t^c)(1 - \lambda)(L_{t-1} + q_{t-1} V_{t-1}) F_t,$$

where r_t^K is the rental rate of capital and $\tilde{w}_t \equiv \int_{z_t^c}^{\infty} w_t(z)g(z)dz/\left[1-G\left(z_t^c\right)\right]$ is the average wage, weighted according to the distribution of the idiosyncratic job productivity. The representative intermediate input producer chooses employment L_t, capital K_t, the number of vacancies to be posted V_t, and the job destruction threshold z_t^c to maximize the present discounted value of real profits: $E_t\left(\sum_{s=t}^{\infty}\beta_{s,t}d_t^I\right)$, where $\beta_{s,t} \equiv \beta^{s-t}u_{\tilde{C},s}/u_{\tilde{C},t}$ denotes the stochastic discount factor of households, who are assumed to own intermediate input firms. The term $u_{\tilde{C},t} \equiv \tilde{C}_t^{-\gamma}$ denotes the marginal utility of consumption.

By combining the first-order conditions for L_t and V_t, we obtain the following job creation equation:

$$\frac{\kappa}{q_t} = (1-\lambda)\,E_t\left\{\beta_{t,t+1}\left[\left(1-G\left(z_{t+1}^c\right)\right)\left((1-\alpha)\,\varphi_{t+1}\frac{Y_{t+1}^I}{L_{t+1}} - \tilde{w}_{t+1} + \frac{\kappa}{q_{t+1}}\right) - G\left(z_{t+1}^c\right)F_{t+1}\right]\right\}. \quad (3)$$

Equation (3) equalizes the marginal cost and the marginal benefit of posting a vacancy. With probability q_t the vacancy is filled; in which case, two events are possible: either the new recruit will be fired in period $t+1$, and the firm will pay firing costs, or the match will survive job destruction, generating value for the firm. The marginal benefit of a filled vacancy includes expected discounted savings on future vacancy posting, plus the average profits generated by a match. Profits from the match take into account the marginal revenue product from the match and its wage cost.

The first-order condition for the job-productivity threshold z_t^c implies the following job destruction equation:

$$(1-\alpha)\,\varphi_t\frac{Y_t^I}{L_t}\left(\frac{z_t^c}{\tilde{z}_t}\right)^{\frac{1}{1-\alpha}} - w\left(z_t^c\right) + \frac{\kappa}{q_t} = -F_t. \quad (4)$$

At the optimum, the value to the firm of a job with productivity z_t^c must be equal to zero, implying that the contribution of the match to current and expected future profits is exactly equal to the firm outside option—firing the worker, paying F_t.[9]

The optimal capital demand implied by the first-order condition for K_t equates the marginal revenue product of capital to its marginal cost: $\alpha\varphi_t Y_t^I/K_t = r_t^K$.

Wage Setting

We assume surplus splitting between an individual worker and the firm. The surplus-splitting rule divides the surplus of each match in shares determined by an exogenous bargaining weight

[9] Equation (4) implies the firm keeps some currently unprofitable jobs occupied. This happens because current job productivity can improve in the future, and the firm has to incur firing and recruitment costs to replace a worker.

$\eta \in (0,1)$, which identifies the workers' bargaining power.[10] The analytical derivation of the wage equation is presented in the online Appendix A. The wage payment is a weighted average between the marginal revenue product of the match (plus a firing costs component) and the flow value of unemployment:

$$w_t(z) = \eta \left[(1-\alpha)\,\varphi_t \frac{Y_t^I}{L_t} \left(\frac{z}{\tilde{z}_t} \right)^{1/(1-\alpha)} + \kappa \vartheta_t + F_t - (1-\lambda)\,(1-\iota_t)\,E_t \beta_{t,t+1} F_{t+1} \right] + (1-\eta)\,(h_p + b_t)\,, \tag{5}$$

where $\vartheta_t \equiv V_t/U_t$ denotes labor market tightness, and b_t is the real value of unemployment benefits– a transfer from the government financed with lump-sum taxes. Firing costs affect the wage payment in the following way: The firm rewards the worker for the savings in firing costs today—the F_t term in the square bracket in equation (5)—but it penalizes the worker for the fact that it will have to pay firing costs tomorrow in the case of firing.

Final Producers

There is a continuum of monopolistically competitive firms, each producing a different variety ω. Following the language convention of most of the macroeconomic literature, we assume coincidence between a producer, a product, and a firm. However, as in Bilbiie, Ghironi, and Melitz (2012), each unit in the model is best interpreted as a production line that could be part of a multi-product firm whose boundary is left undetermined. In this interpretation, producer entry and exit capture the product-switching dynamics within firms documented by Bernard, Redding, and Schott (2010).

The number of firms serving the market is endogenous. Prior to entry, firms face a sunk entry cost $f_{E,t}$, in units of consumption.[11] Sunk entry costs reflect both a technological constraint ($f_{T,t}$) and administrative costs related to regulation ($f_{R,t}$), i.e., $f_{E,t} \equiv f_{T,t} + f_{R,t}$. In every period t, there is an unbounded mass of prospective entrants in the final-goods sector. All firms that enter the economy produce in every period until they are hit by a "death" shock, which occurs with probability $\delta \in (0,1)$ in every period. As noted by Bilbiie, Ghironi, and Melitz (2012), the assumption of exogenous exit is a reasonable starting point for analysis, since, in the data, product destruction and plant exit rates are much less cyclical than product creation and plant entry (see

[10] Following standard practice in the literature, we formulate the problem as though the worker is interested in maximizing expected discounted income. As pointed out by Rogerson, Shimer, and Wright (2005), this is the same as maximizing expected utility if the worker is risk neutral, of course, but also if (s)he is risk averse and markets are complete, since then (s)he can maximize utility by first maximizing income and then smoothing consumption.

[11] None of our results is significantly affected if entry costs are denominated in units of the intermediate input. Results are available upon request.

Lee and Mukoyama, 2008 and Broda and Weinstein, 2010).

Denote with Y_t^C aggregate demand. The latter includes sources other than household consumption but takes the same translog form as the consumption bundle C_t. This ensures that the consumption price index is also the price index for Y_t^C. The producer ω faces the following demand for its output:

$$y_t(\omega) = \sigma \ln\left(\frac{\bar{p}_t}{p_t(\omega)}\right) \frac{P_t Y_t^C}{p_t(\omega)}, \tag{6}$$

where $\ln \bar{p}_t \equiv (1/\sigma N_t) + (1/N_t) \int_{\omega \in \Omega_t} \ln p_t(\omega)\, d\omega$ is the maximum price that a domestic producer can charge while still having a positive market share. Thus, the firm revenue, $p_t(\omega)\, y_t(\omega)$, is a fraction of aggregate demand $P_t Y_t^C$, where the time-varying market share, $\sigma \ln(\bar{p}_t / p_t(\omega))$, depends on the price chosen by the firm relative to the maximum admissible price.

We introduce price stickiness by following Rotemberg (1982). Final producers must pay a quadratic price adjustment cost $\Gamma_t(\omega) \equiv \nu (\pi_t(\omega))^2 p_t(\omega)\, y_t(\omega)/2$, where $\nu \geq 0$ determines the size of the adjustment cost (prices are flexible if $\nu = 0$) and $\pi_t(\omega) \equiv p_t(\omega)/p_{\omega,t-1}(\omega) - 1$. Following Bilbiie, Ghironi and Melitz (2008), when a new final-good firm sets the price of its output for the first time, we appeal to symmetry across producers and interpret the $t-1$ price in $\Gamma_t(\omega)$ as the notional price the firm would have set at time $t-1$ if it had been producing in that period. An intuition for this simplifying assumption is all producers (even those setting the price for the first time) must buy the bundle of goods $\Gamma_t(\omega)/P_t$ when implementing a price decision.[12]

Per-period (real) profits are given by $d_t(\omega) = [p_t(\omega)/P_t - \varphi_t]\, y_t(\omega) - \Gamma_t(\omega)/P_t$. All profits are returned to households as dividends. Firms maximize the expected present discounted value of the stream of current and future real profits: $E_t \sum_{s=t}^{\infty} \beta_{t,s} (1-\delta)^{s-t} d_s(\omega)$, where discounting is adjusted for the probability of firm survival. Optimal price setting implies that the real output price $\rho_t(\omega) \equiv p_t(\omega)/P_t$ is equal to a markup $\mu_t(\omega)$ over marginal cost φ_t: $\rho_t(\omega) = \mu_t(\omega)\, \varphi_t$. The endogenous, time-varying markup $\mu_t(\omega)$ is given by

$$\mu_t(\omega) \equiv \frac{\theta_t(\omega)}{[\theta_t(\omega) - 1]\, \Xi_t(\omega)},$$

where $\theta_t(\omega) \equiv -\partial \ln y_t(\omega) / \partial \ln(p_t(\omega)/P_t)$ denotes the price elasticity of total demand for variety

[12] Thus, new entrants behave as the (constant number of) price setters in Rotemberg, where an initial condition for the price is dictated by nature.

ω, and:

$$\Xi_t(\omega) \equiv 1 - \frac{\nu}{2}\left(\pi_t(\omega)\right)^2 + \frac{\nu}{\theta_t(\omega) - 1}\left\{ \begin{array}{c} \left(\pi_t(\omega) + 1\right)\pi_t(\omega) \\ -E_t\left[\beta_{t,t+1}\left(1-\delta\right)\left(\pi_{t+1}(\omega)+1\right)\pi_{t+1}(\omega)\frac{\rho_{t+1}(\omega)}{\rho_t(\omega)}\frac{y_{t+1}(\omega)}{y_t(\omega)}\right] \end{array} \right\}.$$

There are two sources of endogenous markup variation in our model: First, translog preferences imply that substitutability across varieties increases with the number of available varieties. As a consequence, the price elasticity of total demand facing producer ω increases when the number of producers is larger. Second, price stickiness introduces an additional source of markup variation as the cost of adjusting prices gives firms an incentive to change their markups over time in order to smooth price changes across periods. When prices are flexible ($\nu = 0$), the markup reduces to $\theta_t(\omega) / [\theta_t(\omega) - 1]$.

Producer Entry and Exit Following Bilbiie, Ghironi, and Melitz (2008) and Ghironi and Melitz (2005), we introduce a time-to-build lag in the model and assume that entrants at time t will start producing only at $t+1$. The law of motion for the number of producing firms is given by $N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$. Prospective entrants compute their expected post-entry value e_t, given by the expected present discounted value of the stream of per-period profits: $e_t(\omega) = E_t\left[\sum_{s=t+1}^{\infty}\beta_{t,s}\left(1-\delta\right)^{s-t}d_s(\omega)\right]$. Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition $e_t(\omega) = f_{E,t}$, which in turn implies symmetry across incumbents, i.e., $e_t(\omega) = e_t$ for any ω. In equilibrium, equality of prices across firms implies $p_t(\omega) = p_t$. The real price of each variety, in units of consumption, is $\rho_t \equiv p_t/P_t = \exp\left\{-\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right\}$, where $\exp(X)$ denotes the exponential of X. Producer output is $y_t = Y_t^C/N_t$, while the elasticity of substitution across varieties is $\theta_t = 1 + \sigma N_t$.

Household Budget Constraint and Intertemporal Decisions

The representative household can invest in two types of financial assets: shares in a mutual fund of final-good sector firms and a non-contingent bond (A_t). In addition, the household owns the total stock of capital of the economy. Investment in the mutual fund of firms is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. The profits of intermediate-sector firms are rebated to households in lump-sum fashion.[13]

[13] As long as the wage negotiated by workers and firms is inside the bargaining set (and, therefore, smaller than or equal to the firm's outside option), the surplus from a match that goes to the firm is positive, even if intermediate producers are perfectly competitive. Since all workers are identical, the total surplus of the intermediate sector is

Let x_t be the share in the mutual fund of firms held by the representative household entering period t. The mutual fund pays a total profit in each period (in units of consumption) that is equal to the total profit of all firms that produce in that period, $N_t d_t$. During period t, the representative household buys x_{t+1} shares in a mutual fund of $N_t + N_{E,t}$ firms (those already operating at time t and the new entrants). Only a fraction $1-\delta$ of these firms will produce and pay dividends at time $t+1$. Since the household does not know which firms will be hit by the exogenous exit shock δ at the end of period t, it finances the continuing operation of all pre-existing firms and all new entrants during period t. The date t price of a claim to the future profit stream of the mutual fund of $N_t + N_{E,t}$ firms is equal to the nominal price of claims to future profits of firms, $P_t e_t$.

The household accumulates the physical capital and rents it to intermediate input producers in a competitive capital market. Investment in the physical capital stock, $I_{K,t}$, requires the use of the same composite of all available varieties as the basket C_t. As standard practice in the literature, we introduce convex adjustment costs in physical investment and variable capital utilization in order to account for the smooth behavior of aggregate investment and the pronounced cyclical variability in capacity utilization observed in the data. Thus, effective capital rented to firms, K_t, is the product of physical capital, $\tilde{K}_t$, and the utilization rate, $u_{K,t}$: $K_t = u_{K,t}\tilde{K}_t$. Increases in the utilization rate are costly because higher utilization rates imply faster depreciation rates. Following Greenwood, Hercowitz, and Huffman (1988) and Burnside and Eichenbaum (1996), we assume the following convex depreciation function: $\delta_{K,t} \equiv \varkappa u_{K,t}^{1+\varsigma}/(1+\varsigma)$. Physical capital, $\tilde{K}_t$, obeys a standard law of motion:

$$\tilde{K}_{t+1} = (1-\delta_{K,t})\,\tilde{K}_t + I_{K,t}\left[1 - \frac{\nu_K}{2}\left(\frac{I_{K,t}}{I_{K,t-1}} - 1\right)^2\right], \tag{7}$$

where $\nu > 0$ is a scale parameter. The per-period real household's budget constraint is:

$$\begin{aligned} &A_t + P_t C_t + x_{t+1}(N_t + N_{E,t})P_t e_t + P_t I_{K,t} = \\ &= (1+i_{t-1})\,A_{t-1} + P_t(d_t + e_t)N_t x_t + P_t \tilde{w}_t L_t + P_t r_t K_t + P_t b(1-L_t) + P_t d_t^I + T_t^g, \end{aligned} \tag{8}$$

where i_t is the nominal interest rate on the bond and T_t^g is a nominal lump-sum transfer (or tax) from the government.

The household maximizes its expected intertemporal utility subject to (7) and (8). The Euler equation for capital accumulation requires: $\zeta_{K,t} = E_t\left\{\beta_{t,t+1}\left[r_{t+1}u_{K,t+1} + (1-\delta_{K,t+1})\,\zeta_{K,t+1}\right]\right\}$, where $\zeta_{K,t}$ denotes the shadow value of capital (in units of consumption), defined by the first-order

positive, and so is the profit rebated to households.

condition for investment $I_{K,t}$:

$$\zeta_{K,t}^{-1} = \left[1 - \frac{\nu_K}{2}\left(\frac{I_{K,t}}{I_{K,t-1}} - 1\right)^2 - \nu_K\left(\frac{I_{K,t}}{I_{K,t-1}} - 1\right)\left(\frac{I_{K,t}}{I_{K,t-1}}\right)\right] + \nu_K \beta_{t,t+1} E_t\left[\frac{\zeta_{K,t+1}}{\zeta_{K,t}}\left(\frac{I_{K,t+1}}{I_{K,t}} - 1\right)\left(\frac{I_{K,t+1}}{I_{K,t}}\right)^2\right].$$

The optimality condition for capital utilization implies: $r_t = \varkappa u_{K,t}^{1+\varsigma}\zeta_{K,t}$. The Euler equation for bond holdings implies:

$$1 + \Lambda_t = (1 + i_t)\, E_t\left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}}\right), \tag{9}$$

where the term Λ_t captures a risk-premium shock that affects households' demand for risk-free assets. We assume that Λ_t follows a zero-mean autoregressive process: $\Lambda_t = \rho_\Lambda \Lambda_{t-1} + \epsilon_{\Lambda t}$, where $\epsilon_{\Lambda t} \overset{i.i.d.}{\sim} N\left(0, \sigma_{\epsilon_\Lambda}^2\right)$. As in Smets and Wouters (2007) and subsequent literature, the shock is specified as an exogenous term appended to the representative household's Euler equation for bond holdings. As shown by Fisher (2015), Λ_t can be interpreted as a structural shock to the demand for safe and liquid assets, i.e., Λ_t captures, in reduced form, stochastic fluctuations in household's preferences for holding one-period nominally risk-free assets. The Euler equation for share holdings is $e_t = (1 - \delta)\, E_t \beta_{t,t+1}\,(d_{t+1} + e_{t+1})$.

Equilibrium

In equilibrium, $x_t = x_{t+1} = 1$ and $T_t^g = -P_t b(1 - L_t)$. Aggregate demand of the final consumption basket must be equal to the sum of market consumption, investment in physical capital, and the costs associated to product creation, job creation, job destruction, and price adjustment:

$$Y_t^C\left[1 - (\nu/2)\left(\pi_{\omega,t}\right)^2\right]^{-1} = C_t + I_{K,t} + \kappa V_t + \left[\frac{G\left(z_t^c\right)}{1 - G\left(z_t^c\right)}\right] L_t F_t.$$

Labor market clearing requires: $Z_t \tilde{z}_t K_t^\alpha L_t^{1-\alpha} = Y_t^C/\rho_t$.

Monetary Policy

In the presence of endogenous producer entry and preferences that exhibit "love for variety," an issue concerns the empirically relevant variables that enter the theoretical representation of monetary policy. When the economy experiences entry of firms, the welfare-consistent price index P_t can fluctuate even if product prices, p_t, remain constant—equation (1) implies that

$P_t = p_t \exp\left\{-\left(\tilde{N} - N_t\right) / \left(2\sigma\tilde{N}N_t\right)\right\}$, i.e., the expenditure needed to reach a certain level of consumption declines with N_t. In the data, however, aggregate price indexes do not take these variety effects into account.[14] To resolve this issue, we follow Ghironi and Melitz (2005) and introduce the data-consistent price index, $\tilde{P}_t \equiv P_t / \exp\left\{-\left(\tilde{N} - N_t\right) / \left(2\sigma\tilde{N}N_t\right)\right\} = p_t$. In turn, given any variable X_t in units of consumption, we construct its data-consistent counterpart as $X_{Rt} \equiv X_t P_t / \tilde{P}_t$, implying $X_{Rt} = X_t / \rho_t$, since $\rho_t \equiv p_t / P_t$.

We assume that the central bank sets the nominal interest rate following the rule:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i)\left(1 + \tilde{\pi}_{C,t}\right)^{\varrho_\pi} \left(\tilde{Y}_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}, \tag{10}$$

where i denotes the steady-state value of the nominal interest rate, $1 + \tilde{\pi}_{Ct} \equiv \tilde{P}_t / \tilde{P}_{t-1}$ is the data-consistent CPI inflation, and $\tilde{Y}_{g,t} \equiv Y_{R,t} / Y_R$ is the data-consistent output gap. We use the NIPA definition of GDP as total income: $Y_t \equiv \tilde{w}_t L_t + r_t^K K_t + N_t d_t^N + d_t^I$, which also corresponds to the sum of consumption, physical capital investment, and product creation expenses: $Y_t = C_t + I_{Kt} + N_{E,t}\left(f_{R,t} + f_T\right)$.[15]. In equilibrium, $1 + \tilde{\pi}_{Ct} = (1 + \pi_{Ct})\left(\rho_t / \rho_{t-1}\right)$ and $Y_{R,t} = Y_t / \rho_t = Y_t^I$. We take explicitly into account the possibility that the nominal interest rate cannot fall below some lower bound i^{zlb}, so that in each period $i_{t+1} \geqslant i^{zlb}$. Therefore, the interest rate satisfies:

$$1 + i_{t+1} = \max\left\{1 + i^{zlb}, (1 + i_t)^{\varrho_i} \left[(1 + i)\left(1 + \tilde{\pi}_{C,t}\right)^{\varrho_\pi} \left(\tilde{Y}_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}\right\}.$$

Table 1 summarizes the key equilibrium conditions of the model. The variables s_t, q_t, $\tilde{z}_t$, μ_t, $\tilde{\pi}_{C,t}$, and $\tilde{Y}_{g,t}$ that appear in the table depend on the above variables as previously described.

3 Calibration and Model Properties

We interpret periods as quarters and choose parameter values from the literature and to match features of euro area macroeconomic data from 2000:Q1 to 2019:Q1. Unless otherwise noted, data are taken from the Eurostat database.[16] Below, variables without a time subscript denote steady-state values.

[14] Gains from variety are mostly unmeasured in CPI data (Broda and Weinstein, 2010). Furthermore, the adjustment for variety neither happens at the frequency represented by periods in the model, nor using the specific functional form for preferences that the model assumes.

[15] As discussed by Cacciatore and Fiori (2016), the inclusion of product creation expenses in Y_t is consistent with the fact that intangible capital and nonresidential structures are accounted for in GDP. Moreover, the cost of complying with legal requirements of market entry involves the purchase of goods and services (Djankov, Porta, Lopez-De-Silanes, and Shleifer, 2002).

[16] Data are available at http://epp.eurostat.ec.europa.eu

We use standard values for all the parameters that are conventional in the business cycle literature. We set the discount factor β equal to 0.99, the risk aversion γ equal to 1, the share parameter on capital in the Cobb-Douglas production function α equal to 0.33, the capital depreciation rate δ_K equal to 0.025, and the elasticity of marginal depreciation with respect to the utilization rate ς equal to 0.41. We set the elasticity of matches to unemployment, ε, equal to 0.6, the midpoint of estimates reported by Petrongolo and Pissarides (2006). To maintain comparability with much of the existing literature, we set the worker's bargaining power parameter, η, such that $\eta = \varepsilon$. The scale parameter for the cost of adjusting prices, ν, is set is equal to 80, as in Bilbiie, Ghironi, and Melitz (2008). We set the lower-bound on the nominal interest rate such that $i^{zlb} = 0$ and assume that $\pi_C = 0$.[17] For comparability with Eggertsson, Ferrero and Raffo (2014), we assume a zero-inflation targeting regime, i.e., we set the smoothing parameter and GDP gap weights, ϱ_i and ϱ_Y, equal to zero, and set ϱ_π arbitrarily large.[18]

We calibrate the remaining parameters to match statistics from simulated data to empirical targets. Concerning the parameters that are specific to the product market, we set the firm exit rate, δ, such that gross steady-state job destruction accounted for by firm exit is 20 percent, in line with the estimates in Haltiwanger, Scarpetta, and Schweiger (2006). In order to calibrate the entry costs related to regulation, f_R, we update the procedure in Ebell and Haefke (2009) and convert into months of lost output the OECD indicator for administrative burdens on start-ups (OECD, Product Market Regulation Database). See Appendix B for details. Following this procedure, the aggregate cost of product market regulation is 2 percent of GDP. We choose f_T such that aggregate R&D expenditures are 1.97 percent of GDP (OECD, Science and Technology Database).[19] We set the price-elasticity of the spending share on individual goods, σ, such that the steady-state markup, μ, is 20 percent (Thum-Thysen and Canton, 2015).

We now turn to the parameters that are specific to the conventional search and matching framework. We set unemployment benefits such that the average benefit replacement rate, $b/\tilde{w}$, is 32 percent, a weighted average of unemployment benefits across euro area member countries (OECD, Benefits and Wages Database, 2013). We choose the cost of posting a vacancy, κ, such

[17] The exact level of either the inflation target or the bound on the interest rate is not central for our results. What we need is that a lower bound for the policy rate exists, thus preventing the monetary authority from providing additional stimulus.

[18] None of our results are significantly affected if we calibrate the coefficient of the monetary policy rule using the historical values for the euro area estimated by Gerdesmeier and Roffia (2003). A policy of zero-inflation targeting improves the fit of the model with respect to inflation dynamics at the zero lower bound.

[19] The implied entry cost at the producer level is a loss of 1.3 months of steady-state firm's output. The cost of non-regulatory entry barriers at the producer level is 65 percent of output per worker, a midpoint of the values used by Barseghyan and DiCecio (2011) for the U.S. economy.

that the steady-state hiring cost is 13 percent of the average wage, as estimated by Abowd and Kramarz (2003) for France. Following the argument in den Haan, Ramey, and Watson (2000), we assume that firms experiencing exogenous separations attempt to refill the positions by posting vacancies in the ensuing matching phase. Accordingly, we choose the exogenous separation rate, λ^x, so that the percentage of jobs counted as destroyed in a given year that fail to reappear in the following year is 71 percent, as reported by Gomez-Salvador, Messina, and Vallanti (2004) for the euro area as a whole. We set home production, h_p, the matching function constant, χ, and firing costs, F, to match the total separation rate, λ^{tot}, the unemployment rate, U, and the probability of filling a vacancy, q. We set $U = 0.09$, the average unemployment rate in our sample period, $q = 0.6$, as reported by Weber (2000), and $\lambda^{tot} = 0.036$, in line with the estimates in Hobijn and Sahin (2009). With these calibration targets, firing costs and home production amount, respectively, to 11 and 23 percent of the average wage.[20]

We calibrate the risk-premium shock following Abbritti and Weber (2019). They fit an AR(1) process on risk-premia measures calculated by Gilchrist and Mojon (2017) for the euro area. Consistent with their estimates, we set $\rho_\Lambda = 0.85$ and $\sigma_\Lambda = 0.001$. We set persistence and standard deviation of the aggregate productivity, ρ_Z and σ_Z, to match the volatility and persistence of output. We choose the investment adjustment costs, ν, such that the model reproduces the unconditional volatility of investment relative to output. For the distribution of idiosyncratic productivity shocks, we set the lognormal scale, μ_{z_i}, to zero and choose the shape parameter, σ_{z_i}, to match the unconditional volatility of employment relative to output (den Haan, Ramey, and Watson, 2000; Krause and Lubik, 2007). Table 2 summarizes the model calibration.

Table 3 reports model-implied second moments for several macroeconomic variables and their data counterparts for the euro area. The model matches by construction the unconditional volatility of output, investment, and employment. In addition, the model accounts well for the unconditional volatility of consumption and wage, as well as the comovement between macroeconomic variables and output. In Appendix B, we present second moments for an alternative calibration of the Taylor rule, using the historical estimates in Gerdesmeier and Roffia (2003). The model continues to match well the cyclical behavior of real variables. In addition, it accounts for the relative volatility of the interest rate and inflation and their comovement with GDP. In the next Section, we also show the model also accounts for peak-to-trough dynamics of several macroeconomic variables during

[20] The implied value of F is lower than the average value estimated for European countries, which is typically around 25 percent of yearly wages; see Doing Business Database, World Bank (2008). The reason for this discrepancy is that empirical estimates include severance payments, while, as explained before, the model does not.

the Great Recession, the period in which we study the effects of market reforms at the zero lower bound. Appendix C presents impulse responses following a productivity shock.

4 Market Reforms in Normal Times

We begin to investigate the consequences of structural reforms by studying the dynamic adjustment to market deregulation assuming that the economy is at the steady state. We consider a permanent, unanticipated, reduction of policy parameters in a perfect foresight environment.[21] Given the large size of the shocks, transition dynamics from the initial equilibrium to the final equilibrium are found by solving the model as a nonlinear, forward-looking, deterministic system using a Newton-Raphson method, as described in Laffargue (1990). This method solves simultaneously all equations for each period, without relying on low-order, local approximations.

We assume that policy parameters are lowered to their corresponding U.S. levels, a benchmark for market flexibility. To recalibrate entry costs related to regulation, f_R, we apply the same procedure described in Section 3 on U.S. data. The implied loss of steady-state firm's output is equal to 1 month. We assume that unemployment benefits corresponds to 28 percent of the average wage (OECD, Benefits and Wages Database, 2013), and set firing costs to zero as in Veracierto (2008).

The bottom panel of Figure 1 (continuous lines) shows the effects of a permanent decrease in barriers to entry (f_R). In the aftermath of the reform, output increases, since producer entry increases aggregate demand as producers need to purchase final output in order to pay for sunk entry costs. Consumption declines in the short term, because profitable investment opportunities in new firms induce households to save more, offsetting the positive impact of higher expected future income on current consumption.

As new firms enter the market, fiercer competition erodes the market share of incumbents, who downsize. This reduces the demand for the intermediate input, increasing job destruction. Since remaining jobs have higher productivity, the average real wage increases—averaging out the wage equation (5) yields:

$$\tilde{w}_t = \eta \left[(1-\alpha)\, \varphi_t Z_t \tilde{z}_t \left(\frac{K_t}{L_t} \right)^{\alpha} + F_t - (1-\lambda)\, E_t \left(\beta_{t,t+1} F_{t+1} \right) \right] + (1-\eta)\left(h_p + b_t \right).$$

[21] Market reforms are usually the outcome of legislative processes such that implementation is anticipated by agents when it happens. This notwithstanding, treating reforms as unanticipated shocks remains a useful benchmark for analysis.

Other things equal, higher demand for intermediate inputs and higher average wages increase the real marginal cost, φ_t. As a result, the reform has an inflationary effect, which leads to an increase in the nominal interest rate in the short run. Labor market frictions further propagate the adjustment to deregulation. Since job creation induced by new entrants is a gradual process, the slow reallocation of workers across producers increases unemployment and lowers aggregate output. Once the number of producing firms in the deregulating economy has increased, the reduction in red-tape implies that more resources can be devoted to consumption and investment in physical capital. In addition, as jobs are reallocated to new entrants, unemployment falls, further boosting aggregate demand. The larger number of available products results in higher goods substitutability and lower markups in the long run.

The bottom panel of Figure 2 (continuous lines) plots the dynamic adjustment to a permanent reduction in firing costs. Deregulation, in this case, presents a different intertemporal trade-off. Lower firing costs reduce the profitability of low productive matches, increasing job destruction. At the same time, however, lower firing costs reduce the expected cost of terminating a match, boosting job creation. Since destroying existing jobs is an instantaneous process, while matching firms and workers takes time, employment, output, and consumption decrease in the aftermath of the reform but recover over time. Inflation is essentially unaffected following the removal of firing costs. The reason is that two offsetting forces are at work. On one side, lower aggregate demand reduces prices, other things equal. On the other, since only the more productive workers keep their jobs, and because remaining workers are better paid, marginal labor costs rise. On net, the two effects largely cancel out and the nominal interest rate remains virtually unchanged.

In contrast to a reduction in entry barriers or firing costs, a reform that lowers unemployment benefits does not have short-run contractionary effects. The reason is that lower unemployment benefits reduce the workers' outside option and boost job creation without increasing job destruction. Thus, as shown in the bottom panel of Figure 3 (continuous lines), unemployment gradually falls over time, with beneficial effects for aggregate consumption, output, and investment. Yet, the inflationary pressure remains muted, and the nominal interest rate is virtually unchanged in equilibrium. This reflects again the existence of offsetting effects. On one side, the reduction in the flow value of unemployment leads to wage moderation. On the other side, higher job creation and lower job destruction—which lowers the average productivity of existing matches—put upward pressure on wages.

In the model unemployment benefits are financed with lump-sum taxes; therefore the aggregate

resource constraint is not directly affected by a cut in unemployment benefits. That is, in the model, a cut in unemployment benefits only affects the workers' outside option at the bargaining stage, without directly changing households' income and aggregate demand. Alternatively, we could assume that unemployment benefits are part of the exogenous endowments that contribute to household's income. In this case, the adjustment to a reduction in unemployment benefits would be isomorphic to a reduction in home production. In order to address this issue, we consider an alternative labor market reform, which reduces the value of home production, h_P. We consider a reduction in h_P/w equal to the change in the replacement rate, b/w. As shown in Appendix C, aggregate dynamics mirror the dynamics following the reduction in unemployment benefits. This result suggests, in a highly regulated economy, the beneficial effects on job creation and the destruction implied by a reduction of the worker's outside option dominate the potential costs associated with lower household consumption.

Finally, the bottom panel of Figure 4 (continuous lines) shows the adjustment to a joint reform in product and labor markets. Such a reform has inflationary effects in the first phase of the transition, and it stimulates output and employment immediately.

5 Market Deregulation at the Zero Lower Bound

We next investigate how the short-run transmission mechanism of structural reforms changes in the presence of the ZLB. In our crisis scenarios, we follow the recent literature and assume that an aggregate preference shock (the risk-premium shock Λ_t) depresses output, generating deflation. The central bank provides monetary stimulus until the interest rate hits the ZLB. We then study the consequences of market deregulation in such macroeconomic conditions.

The Crisis and the ZLB

We assume that at time 0 there is an exogenous increase in the risk-premium. We calibrate the size of the shock to reproduce the decline of euro-area output from the collapse of Lehman Brothers until the economy hit the effective lower bound (2008:Q4 - 2009:Q2). We set the persistence of the shock such that the ZLB is binding for approximately two years. Figure 5 shows the adjustment following the risk-premium shock. The model accounts well for peak-to-trough dynamics in output, investment, unemployment, and inflation in the euro area.[22]

[22] Over the period we consider, output drops by 3.2%, investment by 8.3%, and inflation by 0.7%. The unemployment rate increases by 2 percentage points.

To gain intuition about the transmission of the risk-premium shock, recall the first-order condition for bond holdings (9) implies a reduction in Λ_t lowers the marginal cost of saving in the risk-free bond. Thus, the incentive to save through this vehicle increases. As households demand more risk-free bonds, aggregate consumption, investment in physical capital, and producer entry fall. In turn, lower aggregate demand results in lower production and higher unemployment. The central bank immediately cuts the nominal interest rate to its zero lower bound and keeps this accommodative stance for 8 quarters. As the negative demand shock slowly reverts back, the central bank smoothly increases the policy rate toward its long-run value. Consumption, output, and GDP recover.[23]

The Effects of Market Reforms at the ZLB

We now study the consequences of market deregulation at the ZLB. We consider the following experiment. We assume that at quarter 0 the economy is hit by the risk-premium shock described above. Next, we assume that at quarter 1 there is a permanent change in regulation. As before, we consider a permanent reduction in barriers to entry, firing costs, and unemployment benefits, and we treat this policy shock as unanticipated.[24]

The general message of our analysis is twofold. First, the effectiveness of implementing product or labor market reforms in a recession is reform-specific. This result confirms the analysis in Cacciatore, Duval, Fiori, and Ghironi (2016b). Second, and central to the present paper, the inability of monetary policy to deliver large interest rate cuts because of the ZLB is not a relevant obstacle to reform, since reforms do not have deflationary effects. On the contrary, we find that reforms can indeed be more effective in boosting economic activity when the ZLB is binding relative to normal times, stimulating the recovery from the recession and ensuring a faster transition to the new long-run equilibrium.

Consider first the case of a product market reform. The top panel of Figure 1 presents the adjustment when the recession is followed by a reduction in barriers to entry (dashed lines) versus the dynamics in the absence of market reform (continuous lines). The reform has an expansionary effect, since it immediately boosts output and employment. The reason is that, as mentioned above, product market deregulation is inflationary in the short run. Higher inflation, in turn,

[23] The fact that the nominal interest rate returns to its steady-state value smoothly depends on the persistence of the risk-premium shock. We could consider the alternative possibility of a series of *i.i.d.* realizations of Λ_t. In this case, the reversion to the steady state would occur more quickly without affecting the main results of the paper.

[24] This amounts to considering an unanticipated regulation shock assuming that all the state variables of the model take the value implied by the impact response to the risk-premium shock.

lowers the real interest rate, as monetary policy does not fully offset the inflationary pressure in a deep recession.[25] Ultimately, investment and aggregate demand increase. Notice that consumption falls by more initially relative to the scenario without deregulation, since households must finance product creation. Overall, the presence of the ZLB actually contributes to reducing the magnitude of the recession and to a more rapid recovery toward the new steady state.

The bottom panel of Figure 1 (dashed lines) shows the net effect of lowering entry barriers when the economy is in a recession in which the ZLB is binding. We construct the net effect of deregulating markets in a recession as the difference between the dynamics implied by the risk premium shock followed by market reform and the dynamics of the risk premium shock in the absence of deregulation.[26] Relative to normal times (continuous lines), the reform is more expansionary on impact. The reason, once again, relates to the inflationary effect of product market reform. In normal times, the central bank responds to this inflationary pressure by raising the policy rate. By contrast, when the reform occurs in the recession, aggregate demand and inflation are already low. As a consequence, the response of the central bank does not offset the inflationary pressure brought about by the reduction in barriers to entry. Appendix C further illustrates the importance of modeling primitive changes in market regulation to understand the effects of reforms at the ZLB. When an exogenous markup cut captures in reduced form product market deregulation, the conclusion of our analysis is reversed. In particular, consistent with Eggertsson, Ferrero and Raffo (2014), an exogenous markup cut is deflationary, implying a more severe recession when the economy is at the ZLB.

Figure 2 shows the effects of a reduction in firing costs. In contrast to product market deregulation, lowering firing costs deepens the recession. The removal of firing costs further depresses economic activity because increased firing lowers aggregate demand in the short run. Intuitively, firing costs protect relative unproductive workers from layoffs. Thus, facilitating layoffs increases the share of unprofitable jobs that are destroyed, which further depresses aggregate demand and output in the short run. As a result, the reform entails larger and more persistent adverse short-run effects on employment and output when implemented in a recession. Importantly, these initial negative effects do not depend on the presence of the ZLB on the policy rate. The presence of the

[25] In equilibrium, the expansionary effects of the reform are strong enough that the economy exits the liquidity trap.

[26] The responses to the reform at the ZLB and the reform in normal times are aligned so the impact response to the reform at the ZLB (which happens in period 1) is aligned with the impact response to the reform in normal times (which happens in period 0). To show transparently the differences in responses in the same diagram, we are shifting the impulse responses to the reform at the ZLB to the left by one period.

ZLB actually mitigates output and employment losses, since inflation displays (a mild) increase at the zero lower bound, reflecting the larger firing of relative unproductive workers and therefore the higher wage of workers that survive job destruction.[27]

Figure 3 shows the effects of a reduction in the level of unemployment benefits. Unlike the removal of firing costs, a reduction in unemployment benefits stimulates job creation by reducing the outside option of the workers and therefore leading to an increase in firm surplus. Reducing unemployment benefits is more beneficial in a recession independently of the ZLB. Also in this case, this constraint is not central to the dynamics triggered by the labor market reform, since the cut in unemployment benefits also results in a mild increase in inflation at the zero lower bound. In this case, there is a small increase in inflation because a cut in unemployment benefits has a bigger effect on the profitability of job creation when wages are lower to begin with, such as in a recession. As a result, job creation increases more than in normal times, and so does the marginal cost.

Finally, Figure 4 shows a joint reform of product and labor markets is highly stimulative in the short-run—and more so when the ZLB is binding.[28] Overall, the results presented in Figures 1-4 show the consequences of product and labor market reforms in the presence of the ZLB in a model with explicit micro-level product and labor market dynamics are very different from those implied by the reduced-form modeling of structural reforms in Eggertsson, Ferrero, and Raffo (2014) and other studies. Thus, our analysis shows that key for the difference in results is the inflationary effect of reforms (or the absence of any significant deflationary pressure) once the relevant micro-level dynamics of products and labor markets are accounted for.

To conclude, we note that the lack of deflationary effects of market reforms does not depend on the specific shock that triggers the zero lower bound and/or the presence of financial frictions. Results from the existing literature suggest the main results of the paper do not depend on the specific shock that triggers the binding ZLB, nor on the presence of financial frictions. The reason is twofold. First, market reforms may ease credit constraints by increasing expected permanent income. Andrés, Arce, and Thomas (2017) show this is the case by studying the effects of an exogenous reduction in price and wage markups in a model that features credit restrictions and long-term debt. For instance, they find stronger competition and the ensuing long-run gains in consumption

[27] This could also be seen by plotting the effect of the removal of firing costs assuming the central bank can push the policy rate in negative territory without any limit. The output decline is larger when the ZLB is not binding.

[28] As shown in Appendix C, a reform that lowers barriers to entry and unemployment benefits leads to the largest short-run increase in output, both in normal times and at the zero lower bound. This happens since, unlike a full package of simultaneous reforms in the three areas covered in the paper, a package of reforms that focuses only on product markets and unemployment benefits is not undermined by the short-run contractionary effects of lowering firing costs. .

and output can lead (forward-looking) households and firms to increase their investment in the short run. In turn, stronger investment demand alleviates the fall in real income caused by the deleveraging shock, and the recovery in output is faster. The same argument would apply in the context of the present model. Second, abstracting from general-equilibrium effects, credit shocks and financial constraints could weaken the short-run impact of market reforms. However, a weaker short-run impact would not, by itself, result in deflationary–and thus contractionary–effects at the ZLB.[29]

6 Market Reforms, Productivity Dynamics, and Sectoral Linkages

In the last part of the paper, we address an issue that received substantial attention in policy debates: the effects of market reforms on aggregate productivity dynamics. Towards this end, we modify the baseline model to account for input-output linkages in propagating the effects of market reforms. At least for product market deregulation, this is a an important aspect, since reductions in barriers to entry typically occur in the service sector which in turn is a key contributor of manufacturing value added. Thus, market reforms can affect marginal costs in industries that use deregulating sectors's output as an input (e.g., Duval and Furceri, 2018), with consequences for aggregate dynamics, in particular at the zero lower bound.

We introduce two final-consumption sectors. One sector features monopolistically competitive firms that purchase intermediate inputs and produce differentiated varieties, as in the baseline model. In the other sector, perfectly competitive firms combine intermediate inputs and differentiated goods to produce a homogeneous final consumption good.[30] This production structure is consistent with the evidence provided by Boeri, Castanheira, Faini, and Galasso (2006), who document how service industries are a key supplier of the manufacturing sector.[31]

Market consumption, C_t, is now a composite of two sectoral goods, $C_{D,t}$ and $C_{H,t}$:

$$C_t = \left[(1-\alpha_D)^{\frac{1}{\phi}} (C_{H,t})^{\frac{\phi-1}{\phi}} + \alpha_D^{\frac{1}{\phi}} (C_{D,t})^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}},$$

[29] For instance, in the case of a reduction in barriers to entry, the reform could be less effective in a credit crunch, since a smaller number of producers would be able to borrow to finance sunk entry costs other things equal. The argument is similar for a reduction in unemployment benefits and firing costs, since the response of job creation could be dampened when firms are credit constrained.

[30] We assume perfect competition and flexible prices in the second sector for simplicity. Our results are robust to the introduction of price stickiness (details are available upon request).

[31] In an open-economy extension of the model, C_t^M and C_t^S would also capture the presence of tradable (manufacturing) and non-tradable (services) goods. See Cacciatore, Duval, Fiori, and Ghironi (2017) for an analysis of the open-economy effects of market reforms at the ZLB.

where ϕ denotes the constant elasticity of substitution and $0 < \alpha_D < 1$. The consumption-based price index is $P_t = \left[(1-\alpha_D)\left(P_{H,t}\right)^{1-\phi} + \alpha_D\left(P_{D,t}\right)^{1-\phi}\right]^{1/(1-\phi)}$, where $P_{H,t}$ is the price of the homogenous good, and $P_{D,t}$ is the price of the differentiated-goods consumption basket. The domestic demand for the two sub-baskets are $C_{H,t} = (1-\alpha_D)\left(P_{H,t}/P_t\right)^{-\phi} C_t$ and $C_{D,t} = \alpha_D\left(P_{D,t}/P_t\right)^{-\phi} C_t$.

Production of the homogenous consumption good requires both intermediate inputs and differentiated goods: $Y_{H,t} = \left(Y^I_{H,t}\right)^{\xi}\left(Y^D_{H,t}\right)^{1-\xi}$, where $Y^I_{H,t}$ and $Y^D_{H,t}$ denote, respectively, the amount of intermediate inputs and differentiated goods. Under perfect competition, producers take the price of output as given. The optimal choice for $Y^I_{H,t}$ and $Y^D_{H,t}$ implies $\xi\rho_{H,t}Y_{H,t} = \varphi_t Y^I_{H,t}$ and $(1-\xi)\rho_{H,t}Y_{H,t} = \rho_{D,t}Y^D_{H,t}$, where $\rho_{H,t} \equiv P_{H,t}/P_t$ and $\rho_{D,t} \equiv P_{D,t}/P_t$. In equilibrium, $Y_{H,t} = C_{H,t}$ and $1 = (1-\alpha_D)\left(\rho_{H,t}\right)^{1-\phi} + \alpha_D\left(\rho_{D,t}\right)^{1-\phi}$. The price index in the differentiated-goods sector is linked to firm-level prices via $\rho_{D,t} = \rho_t \exp\left\{\left(-\tilde{N} - N_t\right)/2\sigma\tilde{N}N_t\right\}$.

We interpret the differentiated-good sector as the service sector, whereas the homogenous-sector good proxies manufacturing. We calibrate $(1-\alpha_D)$ to match a steady-state output share of 18 percent in manufacturing (from the EU-KLEMS database). We set the share of differentiated goods in the production of the homogenous good, ξ, such that the share of manufacturing value added from services averages forty percent (Boeri, Castanheira, Faini, and Galasso, 2006). This implies setting $\xi = 0.6$.

As shown in Appendix D, output dynamics remain similar to those implied by the one sector model. Figure 6 plots the response of aggregate and sectoral productivity. The first row of Figure 6 presents the dynamics of aggregate labor productivity, $lp_t \equiv Y_t/L_t$, across reforms. Focus on the effects of reforms when implemented at the steady state. A reduction in barriers to entry (first column) leads to the largest long-run productivity gains, while a reduction in firing costs (second column) and unemployment benefits (third column) have more modest effects. Product market deregulation raises labor productivity mostly by increasing the number of non-tradable varieties. Importantly, higher labor productivity is not associated with lower prices because the initial increase in intermediate input demand is strong enough to increase the real marginal cost faced by final producers. The removal of firing costs increases the average productivity of existing matches, since relatively less productive jobs are destroyed. Finally, lowering unemployment benefits has an opposite effect, since the pool of relatively less productive workers increases due to lower wages. This explains why long-run productivity displays a small decline following the reduction of unemployment benefits.[32]

[32] The short-run response of labor productivity is larger relative to the long run. In the case of product market

The second and third rows in Figure 6 present the dynamics of sectoral productivity, corresponding to the ratio of sectoral value added to sectoral employment: $lp_{D,t} \equiv \rho_{D,t} Y_{D,t}/L_{D,t}$, where $L_{D,t}$ denotes the number of workers employed to produce the differentiated goods, and $lp_{H,t} \equiv \left[\rho_{H,t} Y_{H,t} - \rho_{D,t} Y_{D,t}\right]/L_{H,t}$, where $L_{H,t}$ denotes the number of workers employed to produce the homogenous output.[33] The second row in Figure 6 refers to $lp_{H,t}$, while the third row refers to $lp_{D,t}$. There are two key messages. First, the comovement of sectoral labor productivity is positive in response to market reforms. Second, labor productivity in the homogeneous-good sector responds more than in the differentiated-good sector—in particular following a reduction in barriers to entry. Both effects reflect input-output linkages, i.e., the productivity spillovers from the non-tradable sector to the tradable sector.

Figure 6 shows the dynamics of labor productivity are not qualitatively different when market reforms are implemented at the zero lower bound. Thus, our results show that lack of deflationary effects of market reforms coexist with productivity gains even at the ZLB. Quantitatively, short-run responses are larger at the ZLB. In the case of a reduction in barriers to entry, this happens because the reform is more expansionary at the ZLB (implying a more pronounced increase in capital per worker). For labor market reforms, the stronger response does not depend on the ZLB itself, but rather on the fact that deregulation happens in a recession. In the case of firing costs, more unprofitable matches are destroyed when firing restrictions are lifted in a recession, resulting in stronger productivity gains. By contrast, since the cut in unemployment benefits is more expansionary in a recession, labor productivity falls by more, as a larger pool of less productive matches survives job destruction.

7 Conclusions

We studied the consequences of structural reforms when the economy is in a deep recession that triggers the ZLB on nominal interest rates. To this end, we built a model featuring endogenous producer entry, search-and-matching frictions in the labor market, and nominal rigidities. In contrast to the existing literature, we focused on primitive changes in market regulation, namely a

deregulation, this occurs because of higher capital utilization (an increase in capital per worker)—producers rent more capital in order to meet the intermediate-input demand from new entrants, leading households to increase the capital utilization rate. The removal of firing costs leads to stronger short-run productivity gains because job destruction is not immediately accompanied by higher job creation, increasing the average productivity of existing matches.

[33] Notice that GDP is not equal to the sum of sectoral value added, since aggregate value added also includes vacancy and firing costs. However, since the share of vacancy and firing costs over GDP is negligible, the dynamics of labor productivity are in practice equal to the sum of sectoral labor productivity (weighted by the corresponding employment share).

reduction in regulatory costs of entry in the non-tradable sector, employment protection legislation (firing costs), and a decline in the generosity of unemployment benefits. The main conclusion of our analysis is that while business cycle conditions at the time of deregulation matter for the adjustment, the presence of the ZLB itself does not induce recessionary effects of market reforms. In fact, reforms can be more beneficial when the ZLB is binding, as observed for product market and unemployment benefit reforms. This result reflects the fact that reforms do not have deflationary effects in the first place, at least in the short run.

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TABLE 1: MODEL EQUATIONS

(1)	$L_t = (1-\lambda)\left[1-G\left(z_t^c\right)\right]\left(L_{t-1}+M_{t-1}\right)$
(2)	$\tilde{K}_{t+1} = (1-\delta_{K,t})\,\tilde{K}_t + I_{K,t}\left[1-\frac{\nu_K}{2}\left(\frac{I_{K,t}}{I_{K,t-1}}-1\right)^2\right]$
(3)	$N_{t+1} = (1-\delta)\left(N_t+N_{E,t}\right)$
(4)	$M_t = \chi\left(1-L_t\right)_t^{\varepsilon} V_t^{1-\varepsilon}$
(5)	$\rho_t = \exp\left\{-\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right\}$
(6)	$Z_t\tilde{z}_t\left(u_{K,t}\tilde{K}_t\right)L_t^{1-\alpha} = Y_t/\rho_t$
(7)	$Y_t^C = \left(1-\frac{\nu}{2}\left(\pi_{\omega,t}^N\right)^2\right)^{-1}\left[C_t + I_{K,t} + N_{E,t}f_{E,t} + \kappa V_t + \frac{G(z_t^c)}{1-G(z_t^c)}F_tL_t\right]$
(8)	$\frac{\kappa}{q_t} = E_t\left\{\tilde{\beta}_{t,t+1}\left[(1-\eta)(1-\alpha)\left(1-G\left(z_{t+1}^c\right)\right)\varphi_{t+1}Z_{t+1}\tilde{z}_{t+1}\left(\frac{u_{K,t+1}\tilde{K}_{t+1}}{L_{t+1}}\right)^{\alpha}\left(1-\left(\frac{z_{t+1}^c}{\tilde{z}_{t+1}}\right)^{\frac{1}{1-\alpha}}\right)-F_{t+1}\right]\right\}$
(9)	$\frac{\kappa(q_t\eta\vartheta_t-1)}{q_t} = (1-\eta)\left[(1-\alpha)\varphi_tZ_t\tilde{z}_t\left(\frac{u_{K,t}\tilde{K}_t}{L_t}\right)^{\alpha}\left(\frac{z_t^c}{\tilde{z}_t}\right)^{\frac{1}{1-\alpha}}-(h_p+b_t)\right]+(1-\eta)F_t+\eta(1-s_t)E_t\left(\tilde{\beta}_{t,t+1}F_{t+1}\right)$
(10)	$\rho_t = \mu_t\varphi_t$
(11)	$\zeta_{K,t}^{-1} = \left[1-\frac{\nu_K}{2}\left(\frac{I_{K,t}}{I_{K,t-1}}-1\right)^2-\nu_K\left(\frac{I_{K,t}}{I_{K,t-1}}-1\right)\left(\frac{I_{K,t}}{I_{K,t-1}}\right)\right]+\nu_K\beta_{t,t+1}E_t\left[\frac{\zeta_{K,t+1}}{\zeta_{K,t}}\left(\frac{I_{K,t+1}}{I_{K,t}}-1\right)\left(\frac{I_{K,t+1}}{I_{K,t}}\right)^2\right]$
(12)	$\zeta_{K,t} = E_t\left\{\beta_{t,t+1}\left[\alpha\varphi_{t+1}Z_{t+1}\tilde{z}_{t+1}\left(\frac{u_{K,t+1}\tilde{K}_{t+1}}{L_{t+1}}\right)^{\alpha-1}+(1-\delta_{K,t+1})\zeta_{K,t+1}\right]\right\}$
(13)	$\alpha\varphi_tZ_t\tilde{z}_t\left(\frac{u_{K,t}\tilde{K}_t}{L_t}\right)^{\alpha-1} = \varkappa u_{K,t}^{1+\varsigma}\zeta_{K,t}$
(14)	$f_{Et} = (1-\delta)E_t\left\{\beta_{t,t+1}\left[f_{Et+1}+\left(1-\frac{1}{\mu_{t+1}}-\frac{\nu}{2}\left(\pi_t\right)^2\right)\frac{\rho_{t+1}Y_{t+1}^C}{N_{t+1}}\right]\right\}$
(15)	$1+\pi_t = \frac{\rho_t}{\rho_{t-1}}\left(1+\pi_{C,t}\right)$
(16)	$1+\Lambda_t = (1+i_{t+1})\,E_t\left(\frac{\beta_{t,t+1}}{1+\pi_{C,t+1}}\right)$
(17)	$1+i_{t+1} = \max\left\{1+i^{zlb},(1+i_t)^{\varrho_i}\left[(1+i)\left(1+\tilde{\pi}_{C,t}\right)^{\varrho_\pi}\left(\tilde{Y}_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}\right\}$

TABLE 2: CALIBRATION

Variety elasticity	$\sigma = 0.68$	Unemployment benefit	$b = 0.33$
Risk aversion	$\gamma = 1$	Firing costs	$F = 0.05$
Discount factor	$\beta = 0.99$	Matching function elasticity	$\varepsilon = 0.5$
Technological entry cost	$f_T = 1.47$	Workers' bargaining power	$\eta = 0.5$
Regulation entry cost	$f_R = 0.98$	Home production	$h_P = 0.83$
Plant exit	$\delta = 0.004$	Matching efficiency	$\chi = 0.42$
Investment adjustment costs	$\nu = 0.16$	Vacancy cost	$k = 0.11$
Capital depreciation rate	$\delta_K = 0.025$	Exogenous separation rate	$\lambda = 0.036$
Capital share	$\alpha = 0.33$	Lognormal shape	$\sigma_{z_i} = 0.125$
Capital utilization, scale	$\varkappa = 0.035$	Lognormal log-scale	$\mu_{z_i} = 0$
Consumption habits	$h_C = 0.6$	Capital utilization, convexity	$\varsigma = 0.41$

TABLE 3: SECOND MOMENTS

	Data	Model
Output	$\sigma_Y = 1.18$	$\sigma_Y = 1.18$
Consumption	$\sigma_C = 0.52$	$\sigma_C = 0.63$
Investment	$\sigma_Y = 2.74$	$\sigma_I = 2.74$
Employment	$\sigma_L = 0.57$	$\sigma_L = 0.57$
Wages	$\sigma_w = 0.29$	$\sigma_w = 0.42$
Consumption	$corr\,(C_t, Y_t) = 0.97$	$corr\,(C_t, Y_t) = 0.80$
Investment	$corr\,(I_t, Y_t) = 0.69$	$corr\,(I_t, Y_t) = 0.94$
Employment	$corr\,(L_t, Y_t) = 0.96$	$corr\,(L_t, Y_t) = 0.98$
Wages	$corr\,(w_t, Y) = 0.93$	$corr\,(w_t, Y_t) = 0.99$

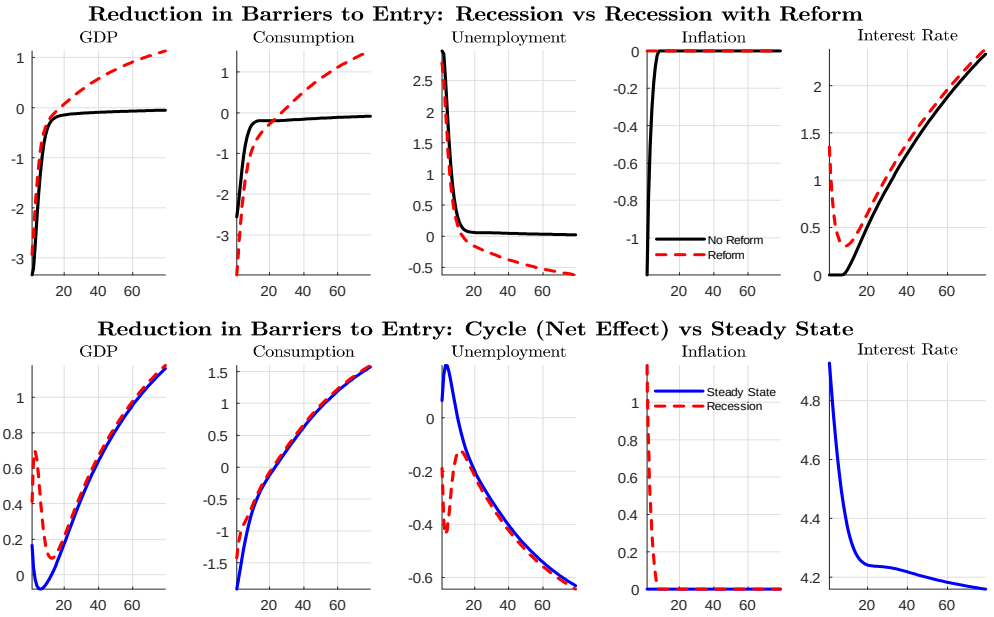

Figure 1. *Top panel*: recession (continuous lines) versus recession followed by product market reform (dashed lines); *Bottom panel*: net effect of product market reform in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state. The inflation and interest rates are annualized and expressed in percentage points.

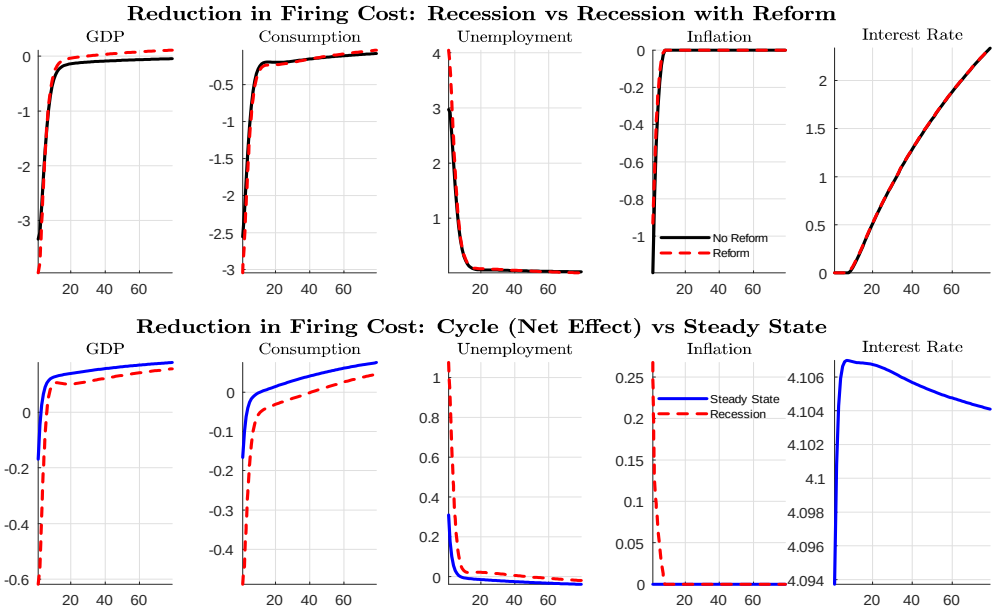

Figure 2. *Top panel*: recession (continuous lines) versus recession followed by firing cost reform (dashed lines); *Bottom panel:* net effect of firing cost reform in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state. The inflation and interest rates are annualized and expressed in percentage points.

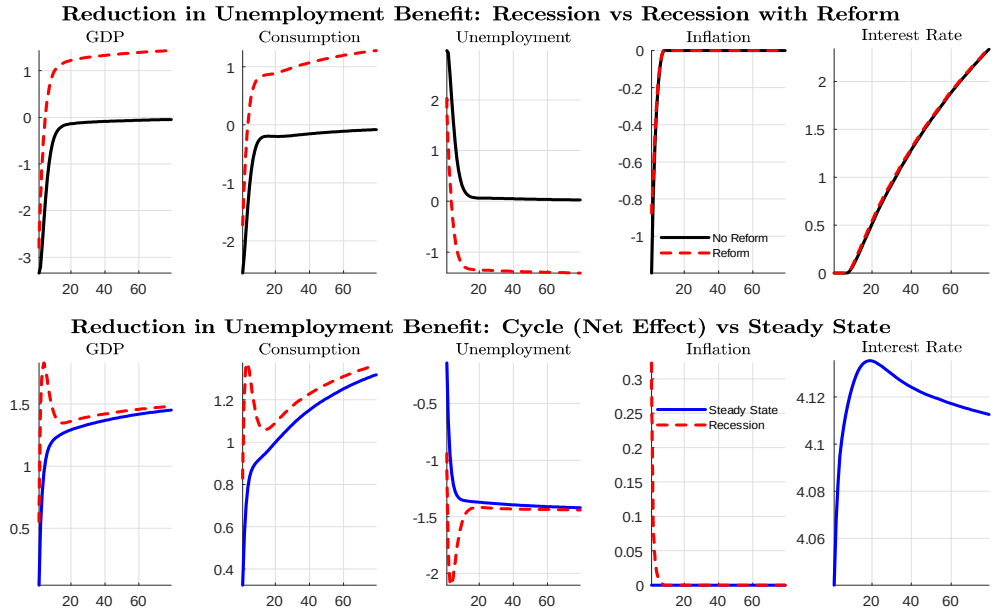

Figure 3. *Top panel:* recession (continuous lines) versus recession followed by unemployment benefit reform (dashed lines); *Bottom panel*: net effect of unemployment benefit reform in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state. The inflation and interest rates are annualized and expressed in percentage points.

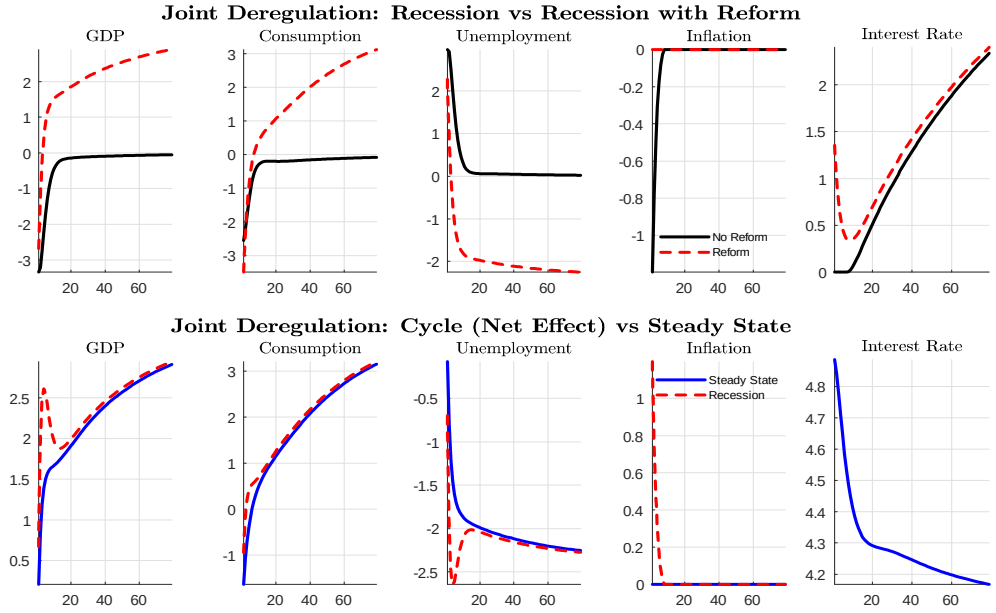

Figure 4. *Top panel:* recession (continuous lines) versus recession followed by joint product and labor market reform (dashed lines); *Bottom panel*: net effect of joint product and labor market reform in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state. The inflation and interest rates are annualized and expressed in percentage points.

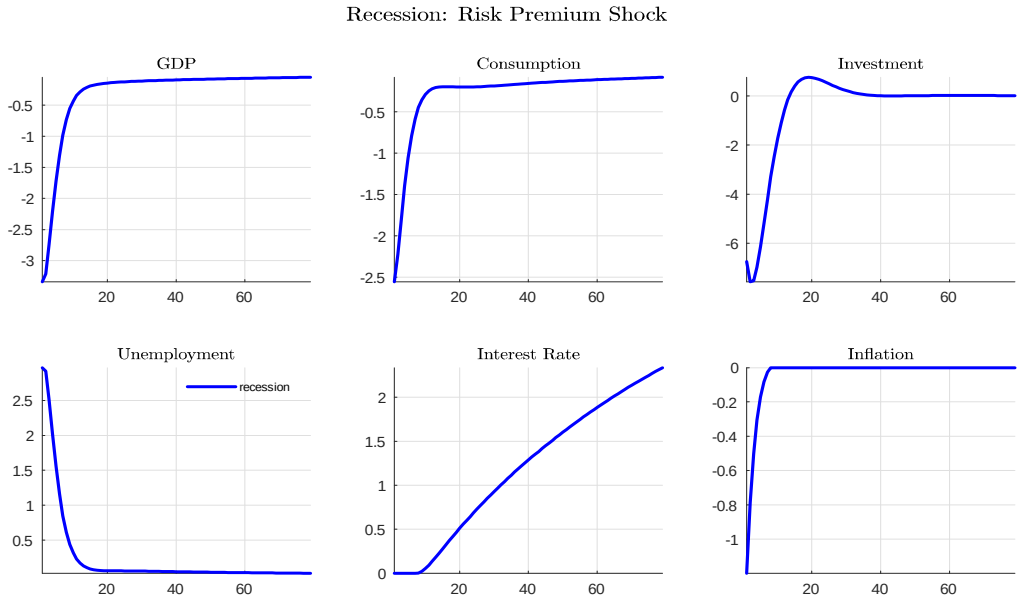

Figure 5. Risk-premium shock with high regulation. Responses show percentage deviations from the steady state. Unemployment is in deviations from the steady state. The inflation and interest rates are annualized and expressed in percentage points.

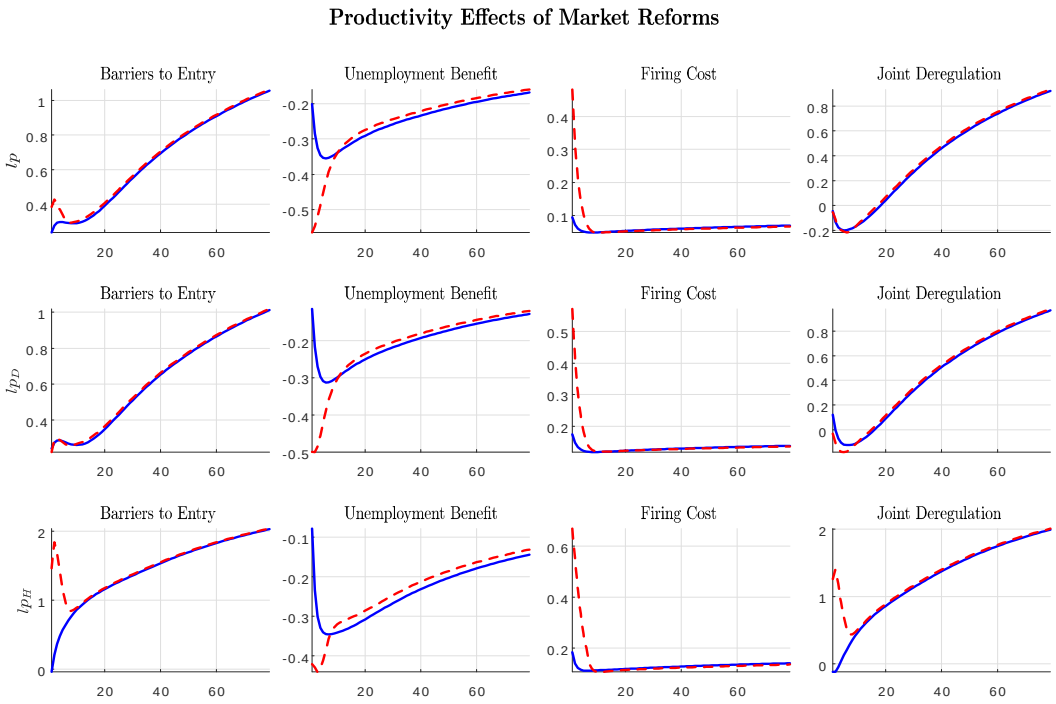

Figure 6. Aggregate and sectoral labor-productivity dynamics following market reforms in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). *First row*: aggregate labor productivity (lp_t); *Second row*: labor productivity in the differentiated-goods sector ($lp_{D,t}$); *Third row*: labor productivity in the homogenous-good sector ($lp_{H,t}$).